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Streamlines simulation of solute mixing in groundwater flow with complex topology

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Mixing of compounds dissolved in groundwater depends on the interplay between pore-scale dispersion and stretching and folding of the volume occupied by the solute due to macroscopic flow variations. Previous experimental and numerical investigations have demonstrated that the combined effect of these transport processes may greatly enhance mixing rates in heterogeneous 2D porous media. Moreover, the same works have demonstrated that transverse dispersion plays a key role in facilitating the action of pore-scale dispersion between adjacent streamlines.

Until now it has been assumed that the enhancement in mixing due to stretching and folding would be greater in 3D domains with complex flow topology, however it has been difficult to test it through numerical simulations due to the difficulty to control numerical dispersion for this kind of setting.

We present results of high resolution 3D numerical simulations performed with a hybrid streamline code which is free of transverse numerical dispersion, while allowing us to include the effect of solute mass exchange between adjacent streamlines. We use the results of the simulations to study the importance of transverse dispersion on the mixing and dilution of solutes dissolved in groundwater with complex flow topologies that arise from anisotropic permeability distributions.

We use the results of the numerical simulations to characterize solute transport in terms of different parameters such as: moments of breakthrough curves, peak concentrations, etc; for a range of transverse dispersion coefficients. Based on these results we demonstrate the importance of transverse dispersion in transport processes in complex 3D groundwater flow fields.